

PATENT SPECIFICATION

DRAWINGS ATTACHED

877,083



Date of Application and filing Complete Specification :
October 2, 1957.

No. 30918/57.

Application made in United States of America on
October 4, 1956.

Complete Specification Published September 13, 1961.

Index at Acceptance: Classes 95, A5, B4(B:C:X); 97(1), J11C; and 140, E1E.
International Classification: B05. C09d. G02d.

Improvements in or relating to coating glass beads for reflex reflectors.

COMPLETE SPECIFICATION

We, MINNESOTA MINING AND MANUFACTURING COMPANY of 900 Bush Avenue, Saint Paul 6, Minnesota, United States of America, a Corporation organised under the laws 5 of the State of Delaware, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to improvements in reflex reflectors in which a layer of small glass beads or sphere lenses are positioned in optical connection with light reflecting 15 means underlying their back extremities, so that a large proportion of an incident ray of right striking the surface of the structure is returned by refraction and reflection in a brilliant cone having its axis common to the 20 axis of the incident ray, even though the incident ray strikes the structure at an angle to the perpendicular. More particularly, this invention relates to improved sphere lenses useful in making reflex reflecting structures 25 and to a method for making these sphere lenses.

The sphere lenses of this invention are composite two-element transparent structures having an inner transparent glass bead 30 core of generally high refractive index coated with an adherent concentric transparent layer of lower refractive index. The coating may serve primarily as a space coating to impart to the composite sphere lens 35 an effective refractive index higher than the refractive index of its core, or it may serve primarily to impart colour to the composite sphere lens, or it may serve both functions.

The coating of bead cores with the primary objective of providing an increased effective refractive index is commonly referred to as space coating in this art. The desirable thickness of a space coating on a bead core is a function of the diameter of 45 the bead core and the particular refractive

index exhibited by the bead core, and will vary depending upon the results desired in a reflex reflective sheeting.

The problem of providing optically satisfactory uniform space coatings about glass beads is highly complex. The minute size of small glass beads particularly complicates the problem. Millions of the smaller beads are required to fill a cubic foot. A monolayer may comprise many thousands per square inch. For best results in terms of 50 desired optical performance properties in the finished reflex reflecting structure, the space coating about each bead should be of essentially uniform thickness, and there should not be a wide variation in the coating thicknesses on graded beads. A coating thickness variation of as little as 10^{-5} inch has a significant effect on optical properties (i.e., the "effective refractive index") of 55 beads 50 microns or less in diameter. Bead cores having generally high refractive indices, e.g., refractive indices on the order of 2.2 or above, present a particularly difficult problem in space coating inasmuch as 60 the desired coating should be but a minor fraction of the diameter of the bead if a resulting effective refractive index of about 2.9 is desired, and yet the coating must be essentially uniform. Additionally, coating 65 must be accomplished in such a manner as to avoid agglomeration or sticking together of beads, and it must be accomplished in a manner that is practical for commercial operations in order to be useful in this art. 70

It is to problems such as the foregoing 75 that this invention provides a practical solution.

According to the invention transparent sphere lenses are formed by atomizing a slurry containing small transparent glass beads dispersed in an aqueous solution of a soluble silicate into particles which consist of a glass bead coated with the aqueous solution, at least partially drying the coat- 80 85 90

(Price)

ings by removing the water while the particles are falling freely, collecting the particles and drying at an elevated temperature above the boiling point of water to rigidify 5 the coatings.

The beads thus made are formed to have a transparent concentric coating of essentially uniform thickness. The composite sphere lens elements formed according to 10 this invention possess desired permanence and stability of structure, and resist abrasion in use.

The coatings about the beads are not dependent upon residual materials remaining 15 in the glass structure of the bead after leaching its outer surface, as they usually are. Moreover, the sphere lenses, as compared to the usual leached beads, have been found to impart greater brilliance of reflex 20 reflection to signs and markers in which they are used.

The beads may be provided with transparent coatings of a wide variety of colours and hues so as to impart varied attractive 25 and brilliant night-time, as well as daytime, colour effects to signs and markers where they are used. Also, reflex reflecting structures of improved angularity can be formed using the sphere lenses.

30 Coatings formed about beads using the process of this invention, instead of containing large pores (as, indeed, might be expected when one considers the preferred process of manufacture employed), are 35 essentially smooth and uniform in nature, which makes it possible to provide the coated beads with smooth hemispherical reflective coatings of aluminium, or other materials, using vapour deposition techniques.

40 The manufacturing process is economical, simple, and commercially practicable, and yet is surprisingly effective to provide essentially uniform concentric coatings of controlled thickness about minute spherical elements.

In the illustrative embodiment shown in the drawings:

Figure 1 is an exaggerated diagrammatic 50 cross section through a composite sphere lens in accordance with the invention;

Figure 2 is a diagrammatic illustration 55 of reflex reflection, showing the return of light in a brilliant cone, illustrated as bounded by a and a' , having its axis essentially common with the incident ray b striking the flat reflex reflecting structure; and

Figures 3 to 5 are highly magnified diagrammatic views in cross section of various 60 illustrative reflex reflecting structures of this invention, employing sphere lenses in accordance therewith.

The sphere lens elements of the present invention can be used to impart improved 65 properties to other reflex reflecting struc-

tures in addition to those described.

The sphere lens 10 has a spherical transparent glass bead core 11 and an adherent transparent in situ formed coating 12 concentrically about the glass bead core. The 70 glass bead core is usually not greater than 125 microns in diameter (a micron being a thousandth of a millimeter) and is preferably in the range of 10 to 100 microns in diameter. Bead cores of larger diameter 75 than 125 microns, when coated according to this invention, do not seem to impart noteworthy additional improvements to most reflex reflectors so as to necessitate their use in such structures. However, such larger bead cores may be used if desired. As an illustration, bead cores as large as about 750 microns in diameter have been coated successfully using the process of the present invention. 80 85

The coating 12 varies in thickness according to the desiderata for increased effective refractive index, spacing coatings being, necessarily, an optically significant fraction of the total diameter of the sphere lens. 90 Coatings employed primarily to impart colour to a sphere lens need be only of the order of a micron in thickness.

The composition of the coating 12 may vary slightly, depending upon slight variations in its method of manufacture, as will be explained; but for purposes of description, the preferred coating may be considered as consisting essentially of silica gel in a substantially dry condition, even though small amounts of alkali, as well as colour pigment, may form a small proportion thereof. In a less preferred embodiment of the invention, the amount of sodium, or equivalent, remaining in the coating is somewhat larger, but still forms only a minor proportion of the coating. In all cases, the coatings analyze chemically to contain at least a major proportion, i.e., well over 50% by weight, of silica. 95 100 105

The coating is a continuous essentially uniform film, optically homogeneous in that it permits the passage of light waves without substantial or significant refraction of the waves internally within the coating per se. 110 Light waves, however, are refracted at interfaces between surfaces of the coating and adjacent light transmitting media of different refractive index (e.g., between the coating and the bead core). The coating appears to be a smooth continuous film even when magnified 400 times, any submicroscopic pores, if present, being insufficient materially to affect desired physical and optical properties. 115 120

The refracting index of the coating varies somewhat, depending upon slight variations in its method of manufacture, but for the most part is, advantageously, substantially the same as that of materials used in many 125 130

- known reflex reflecting structures for transparent covering coatings (i.e., about 1.5). Specifically, the refractive index of the coating varies from about 1.46 to 1.5. While the 5 coating is of a refracting index lower than that of the core, a space coated core of this invention exhibits an effective refractive index higher than the refractive index of the underlying glass bead core. Of course, if a 10 thin coating is applied to the core primarily to impart colour to the resulting sphere lens, no particular or significant increase in the effective refractive index of the composite may be noticeable.
- 15 The coating of the glass cores is accomplished according to this invention by mixing glass beads in an aqueous solution of a soluble silicate, preferably an alkali silicate, described more fully below, and atomizing the mixture into individual particles. Since atomization is accomplished by spraying the mixture, it is surprising that the beads end up with any coating at all. One might expect that the solid beads and liquid 25 soluble silicate would separate during spraying. Surprisingly, however, atomization, as explained below effectively provides individual particles consisting of a bead core surrounded by a soluble silicate coating.
- 30 The atomized particles are maintained in a free falling condition, and while free falling, are at least partially dried. The dried particles are then collected and, when an alkali silicate has been used, preferably treated 35 with an aqueous solution of an acid substance reactive with the alkali portion of the coated soluble silicate so as to remove most of the alkali portion thereof. Thereafter, the particles are dried by heating 40 them to an elevated temperature above the boiling point of water but below any temperature causing devitrification of the glass of the core, or melting and fusion of the applied coating. Durable, weather resistant, 45 chemically resistant sphere lenses are formed by this process. Where the durability, weather resistance and chemical resistance of a coated bead core can be sacrificed to some extent, the treatment with acid substance 50 may be omitted.
- Glass beads for the process may have any desired glass composition but will generally have refractive indices of at least 1.7. For space coating purposes, if the resulting 55 sphere lens elements are to be used in reflex reflective structures which are top coated so as to provide a flat exposed front surface, the refractive index of the beads to be coated is preferably at least 1.9 or higher.
- 60 Beads of a refractive index much below about 1.9 require extremely thick coatings for proper spacing relationships in these structures (i.e., coatings as thick as more than 100% of the bead diameter), and thus 65 their use in such structures is impractical.
- As the refractive index of the beads to be coated for use in such structures is increased, the required thickness for the spacing coat decreases, beads of a refractive index of 2.9, theoretically, not requiring a spacing coat for such reflex reflector use. Few beads of extremely high refractive index, however, are known; and those known are usually expensive to manufacture because of the nature of the raw materials needed for their composition. For that reason, it becomes commercially practicable to employ beads of a somewhat lower, but still high, refractive index, and to space coat them so that they exhibit an effective refractive index of about 2.9 for such reflex reflecting structures. 70
- Of course, while space coating of extremely high refractive index beads may not be necessary, they may be coated according to this invention for the primary purpose of imparting colour. Likewise, while beads of a refractive index as low as about 1.7 or even lower, are not ordinarily space coated in this art (i.e., coated with a sufficient thickness of material to provide an effective refractive index for the composite which is somewhat higher than the refractive index exhibited by the core), the invention may be used for such a purpose 75 as well as to impart colour. It will be apparent, therefore, that space coating of bead cores, as the term "space coating" is employed herein, is not necessarily limited to the formation of sphere lenses which exhibit an effective refractive index of 2.9, or of the order thereof, but includes the formation of sphere lenses which exhibit other, even substantially lower, effective refractive index values, and which are suitable for use in reflex reflecting structures designed for certain specialized effects. 80
- Sodium silicate will ordinarily be used as the soluble silicate for coating as taught herein because of its availability and economy; however, equivalent soluble silicates, e.g., potassium silicate, are suitable to employ. The ratio of the alkali to silica, e.g., Na_2O to SiO_2 , in the silicate may vary considerably, usually being within the range of about 1:2 to 1:4, a ratio of about 1:3.75 giving particularly good results. In general, soluble sodium silicate which has a low ratio of Na_2O to SiO_2 is preferred from the standpoint of its reduced alkalinity which permits neutralization to be accomplished with less acid; however, as the ratio of Na_2O to SiO_2 becomes extremely low, the silicate becomes less soluble and problems arise with respect to maintaining it in a 90 suitable aqueous solution. The concentration and viscosity of a soluble silicate in water may be varied to achieve different coating thicknesses, the more concentrated and viscous solutions being employed advantageously. 95
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geously for thicker coatings. Preferred concentrations for sodium silicate in water, as a general rule, lie within the approximate range of 20 to 40% by weight, the higher concentrations being readily attainable at raised temperatures.

A small amount of transparent colouring material such as for example, phthalocyanine green, phthalocyanine blue, and pastes marketed by the E.I. du Pont de Nemours & Co. under the trade names "Lithosol Red CSP," "Lithosol Fast Yellow 3GD" and "Lithosol Orange OTP," may be incorporated in the sodium silicate solution, or equivalent, to impart colour to the composite sphere lenses. Colour pigments or materials employable may be water soluble or insoluble; however, they are preferably somewhat soluble and should be at least readily dispersible in the aqueous solution of soluble silicate. Colouring mixtures may contain up to 10% by weight of colouring solids based upon the weight of soluble silicate in the solution. Colouring materials are, of course, sufficiently resistant to heat so as to withstand the temperatures employed in drying the coating.

In carrying out the process of the invention, the glass beads or cores are thoroughly dispersed, as by stirring, in a soluble silicate solution (e.g. sodium silicate) to form a slurry, and are maintained uniformly dispersed in the mixture while the mixture is atomized into a drying chamber. Usually the glass cores to be coated will account for at least 50% by weight of the slurry. Atomization of the slurry into small droplets each consisting of a glass bead core surrounded with a layer of the silicate solution is suitably accomplished by spraying the mixture under pressure through a fine orifice nozzle using auxiliary air, under pressure, to break the mixture into droplets as it emerges from the spray nozzle. While the pressure of this auxiliary air will be set sufficiently high to break the mixture into droplets it will not be so high as to cause the silicate solution to be blown free from the beads.

The use of auxiliary air to break the slurry into droplets is not absolutely necessary in all cases; thus, if desired, one may in some cases employ sufficiently high pressures to force the slurry through the nozzle and simultaneously break it into droplets.

The mixture or slurry may be sprayed at room or elevated temperature. The viscosity of the slurry drops rapidly upon heating, which aids in atomizing the slurry; therefore, in the usual case it is preferable to employ slightly elevated slurry temperatures, e.g., 150°F. or so, to accomplish atomization.

As soon as the particles of slurry are formed by spraying, surface tension forces

tend to cause the fluid coatings about the glass cores to become essentially uniform in thickness. The particles of slurry are immediately subjected to drying conditions while they are free falling, that is, while they are moving freely through space. Drying can be accomplished at room or elevated temperatures. Flash drying at greatly elevated temperatures is not preferred inasmuch as it generally causes the formation of brittle and uneven coatings which adhere poorly to the bead core. Air temperatures up to those near the boiling point of water are suitable to employ in drying. In the drying chamber the beads fall freely through the air until their coatings have sufficiently gelled as a result of loss of water so as not to stick to the walls of the chamber nor cake into an aggregate when collected.

After this drying step, the coated beads are preferably treated with an acid substance in aqueous solution to neutralize the coatings by reacting with the alkali constituent thereof to cause the formation of a silica gel. The coated beads are mixed with violent agitation in a water solution containing an amount of acid substance calculated on a molar basis to be sufficient to react with most or substantially all of the alkali portion of the coatings on the beads and effect substantial neutralization thereof. Treatment is usually accomplished at somewhat elevated temperatures, e.g., above 100°F. up to the boiling point of water. The time allowed for neutralization to take place will vary depending upon such factors as the concentration of the acid substance employed, its ability to react with most of the alkali portion to remove the same and the extent of neutralization desired, a time of about one hour at about 200°F. ordinarily being adequate when solutions of sufficient concentration of acid substance are employed. Various acid substances may be used to effect substantial neutralization. Hydrochloric acid, ammonium chloride, nitric acid and sulphuric acid are but illustrations of useful acidic materials. Aqueous solutions of acidic chlorides are especially desirable to employ in neutralization inasmuch as the resulting chloride salt, e.g., sodium chloride, is readily soluble in water and easily removed from the coated beads.

The coated beads are then separated from the acid wash and dried at an elevated temperature above the boiling point of water but below temperatures causing devitrification of the glass bead core, e.g., usually not over about 700°F., so as to drive out substantially all of the water in the silica gel coating, shrink the coating and leave it in a rigid adherent tough transparent condition about the bead cores. The temperature of drying is, of course, well below temperatures at which the glass of the bead core

- melts, as well as below temperatures at which the coating on the core melts and flows. In most cases drying can be accomplished satisfactorily and adequately at temperatures below about 400°F. within one or two hours time. If the acid treatment is omitted, drying as aforescribed serves to rigidify the coating and tends to render it very difficultly soluble in water.
- 5 As a specific preferred illustration of the process, transparent glass beads of minute diameter (i.e., 90% of the beads ranging from 18 to 26 microns in diameter) having a refractive index of 2.49 (the beads analyzing 67.5% lead oxide and 32.5% titanium dioxide), were mixed in a water solution of sodium silicate to form a slurry containing about 67% by weight of beads and 33% sodium silicate solution. The sodium silicate had a ratio of Na₂O to SiO₂ of 1 : 3.75 (obtained from the Philadelphia Quartz Company under the trade designation "S-35"), and was at a concentration of 33% sodium silicate solids in water solution.
- 10 The slurry was placed in a closed container under pressure and maintained at a temperature of 150°F. It was continuously agitated to keep the beads in suspension, and was sprayed through a 0.0625 inch
- 15 nozzle using a pressure of 6 pounds per square inch in the closed container so as to maintain a continuous supply of slurry to the nozzle. As the slowly moving slurry emerged from the spray nozzle, air from a suitable source under a pressure of 60 pounds per square inch was directed through an orifice concentric with the spray nozzle, as well as also through separate orifices which directed jets of air at an angle
- 20 40 through the emerging slurry. The air flow through the orifice concentric with the emerging slurry, and therefore parallel to its movement, served primarily to speed up its movement, whereas the jets of air directed
- 25 45 at an angle through the emerging slurry served primarily to break it up into droplets containing a central bead core surrounded by a film of sodium silicate. A suitable spray gun to accomplish atomization as
- 30 50 here described is one marketed by Binks Manufacturing Company of Chicago, Illinois. Binks Model Number 18 Pressure Cup Spray Gun, with Number 65P air cap, and Number 66 nozzle, has been found satisfactory.
- 35 55 The slurry was sprayed directly into a drying chamber where the droplets moved or fell freely through air held at about 150°F. until the sodium silicate coatings gelled as a result of loss of water. The time
- 40 60 that the droplets were free falling was about ten seconds. Immediately after the droplets were formed and while they were free falling, surface tension forces acted in a manner to cause each bead to be
- surrounded by a concentric layer of silicate.
- 45 After this initial drying, the coated beads were collected and added slowly and with violent agitation to a 30% ammonium chloride solution in water, the ratio of beads to acid solution being about 3 to 1 by weight. With continued agitation, the mixture was raised to 200°F. and maintained at this temperature under agitation for one hour, after which the resulting water solution was decanted from the beads. The product was then filtered to remove further water, together with constituents dissolved therein, and dried by heating to 350°F. for one hour. The resulting glass bead cores had concentric, transparent, uniform coatings consisting essentially of substantially dried silica gel. They contained only a trace of residual sodium. The coatings on the beads were, on the average, about 2 microns in thickness, and the composite elements exhibited effective refractive indices of about 2.9, indicating that the beads were suitably space coated for reflex reflector use in structures employing a flat top coating (see Figure 5) of a refractive index of about 1.5 without requiring a special flat spacing layer over the back reflector.
- 50 It will be readily appreciated that by using increased concentrations of sodium silicate, thicker coatings about beads can be formed. Alternatively, if desired, the thickness of a coating can be built up layer by layer upon bead cores, by repeating the process several times to achieve desired thicknesses.
- 55 A major advantage of the process is the facility with which sphere lenses of optimum optical properties can be prepared in various colours. It is now possible to prepare durable weather resistant sphere lenses in a wide variety of colours and hues. To coat glass beads with a colour pigment the desired pigment (e.g., 3% by weight of phthalocyanine green solids based on the weight of soluble silicate in solution) is merely added to the soluble silicate solution employed in coating.
- 60 The sphere lenses of this invention are useful as elements in a wide variety of reflex reflecting structures. They are useful as lens elements in reflex reflecting liquid paint and lacquer finishes which are adapted to be applied, as by spraying, to a wide variety of surfaces.
- 65 70 As an illustration of reflex reflecting structures of improved angularity and brilliance made possible by this invention, the simplified structure of Figure 3 will first be taken. Here the sphere lens elements 10 are bonded in a layer 13 having a reflective pigment such as titanium dioxide dispersed therethrough. The reflective pigment does not cover the exposed lenticular surface of the structure, and thus a beam of light from
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any suitable source striking the structure, either at an angle from the perpendicular as illustrated in Figure 2, or directly perpendicular to the structure, passes through the 5 sphere lens elements to the reflective pigment where it is reflected and returned back through the sphere lens elements, and emerges in a brilliant cone, the axis of which is essentially common with the incident ray. As illustrated in Figure 3, a thin transparent protective layer 14, suitably of a refractive index lower than that of the bead cores of the sphere lenses employed, may be applied over the structure; however, 10 15 such layer may be omitted. Structures which have a lenticular exposed surface, as illustrated in Figure 3, are preferably formed by using composite sphere lens elements, as taught herein, which have effective refractive indices of about 1.9, although elements of higher refractive index may be dispersed in the layer so as to impart varied properties to the sheet.

In Figure 4 a further structure is illustrated comprising a transparent binder layer 15, which may be coloured or clear, and in which are embedded the sphere lens elements 10, each being hemispherically coated with a layer 16 of reflective material such 20 25 30 as, for example, silver (such being suitably accomplished by vapour deposition of silver upon the sphere lens elements after previously pressing the elements part way into an easily removed temporary binder material, and thereafter, separating the elements from the temporary binder material). As illustrated in Figure 4, the hemispherically coated sphere lens elements may assume random orientation in the binder layer 15, 35 40 45 but a sufficient number of elements are in suitable position for desired reflex reflection. The simple structure such as here illustrated can be made to exhibit any of a wide variety of colours. As in the case of the lenticular structure of Figure 3, this lenticular structure of Figure 4 preferably is formed using at least a substantial proportion of sphere lens elements which exhibit effective refractive indices of about 1.9.

Figure 5 illustrates a smooth or flat surfaced structure (i.e., a non-lenticular surfaced structure) having a binder layer 17 in which a reflective pigment is dispersed and in which a layer of the sphere lens elements 10 are bonded in position so that only their back extremities are in contact with and surrounded by the material of the layer 17. Between the sides of the elements 10 and overlying the reflective pigment layer 50 55 60 65 17 is a colour layer 18 which does not cover the top or uppermost extremities of the sphere lens elements 10. Over the exposed sphere lens elements and colour layer 18 is a transparent protective layer 19 which provides a flat front face for the structure.

Sphere lens elements for use in this structure preferably have effective refractive indices approaching about 2.9 whenever flat transparent cover coatings of a refractive index around 1.5 are employed. The ratio 70 of the refractive index of a bead core to the refractive index of a flat transparent cover coating is desirably 1.15 or above, the preferred ratio being 1.9. Sphere lens elements having effective refractive indices 75 of about 2.9, when used with transparent cover coatings having a refractive index of about 1.5, inherently satisfy this preferred ratio requirement.

Various materials may be used to fabricate the structures illustrated. N-butyl-methacrylate polymer resin and mixtures of this resin with various other resins are examples of suitable binder material or clear transparent cover coating material. 80 85 Others will readily suggest themselves.

The structure of Figure 5 will be readily recognized as one adapted to provide a colour under night-time reflex reflecting conditions which is different from that exhibited 90 by day. At night, light from the headlights of a car (a typical source of light) will strike the sign, pass through the sphere lenses, and be reflected back to the occupants of the car. The colour of the sphere lenses, i.e., 95 the coated cores formed as described in combination with the colour, if any, of reflective material in binder layer 17, will govern the colour exhibited by the sign under night reflex reflection viewing conditions. During the day, however, the colour of the pigment in the layer 18 will largely influence the colour exhibited by the sign, although the colour of the sphere lens elements 10 may, in certain colour combinations, influence the total colour effect experienced by an observer.

The simplified structure of Figure 4 is also readily adaptable to produce such a result. To illustrate, a blue sphere lens element, i.e., a bead core coated with blue pigment, will cause brilliant blue to be the colour of the sign of Figure 4 under night-time reflex reflection, yet the colour of the sign during the day will to a rather large extent be influenced by the colour of any pigment settled behind and between the beads in the binder layer 15, or by the colour of a backing material to which the structure is applied if this binder layer is transparent. Of course, the colour of the sphere lenses employed will, in most colour combinations, influence the daytime colour of the sign, frequently causing it to appear a colour not exactly that of the pigment between the sphere lenses. This may be taken advantage of to produce unusual effects. For example, by employing yellow and blue combinations, i.e., yellow sphere lenses bonded in a blue pigmented layer, the 100 105 110 115 120 125 130

total effect during the day (by balancing pigment quantities and the density of the sphere lenses in the structure) will be greenish, while night-time reflex reflection will bring out a brilliant yellow.

- The present process has also been used to make composite reflex reflecting elements having a central glass bead core, a coating of a reflective material such as, for example,
- 5 10 aluminium over a part, usually hemispherical, of the glass bead core, and a substantially uniform layer formed as described above, completely surrounding the hemispherically coated core. Likewise, a glass bead core coated with a layer of silica gel or a layer analyzing to contain a major proportion of silica, as aforescribed, may then be coated with a hemispherical coating of a reflective material; and thereafter, the composite may be coated with an additional layer of silica.

These composite reflex reflecting elements are particularly useful in rendering various fabrics and other surfaces reflective. This 25 may be done by applying a binder layer upon fabric or the like, and then pressing the composite reflex reflecting elements into the binder layer. Because these composite reflex reflecting elements can be formed 30 with colour materials in their coatings, reflective fabrics which exhibit eye-appealing colours both by day and by night can be formed.

WHAT WE CLAIM IS:

- 35 1. A process for making transparent sphere lenses which includes the steps of atomizing a slurry containing small transparent spheres in a aqueous solution of a soluble silicate into particles 40 which consist of a glass bead coated with the aqueous solution, at least partially drying the coatings of the beads by removing water while the particles are free falling, collecting the particles and drying at an 45 elevated temperature above the boiling point of water to rigidify the coatings.
2. A process according to claim 1 in which the aqueous solution of soluble silicate contains a colouring material.
- 50 3. In a process according to claim 1 or claim 2 in which the silicate is an alkali silicate and a substantial proportion of the alkali is removed from the coatings after the coating has gelled.
- 55 4. A process for making transparent sphere lenses according to claim 1 substantially as described herein.
5. Transparent sphere lenses suitable for use in reflex reflecting applications as herein 60 described and made by the process of any

preceding claim, the sphere lenses each comprising a small transparent glass bead having a diameter not substantially in excess of 750 microns and an adherent transparent coating of substantially uniform thickness completely surrounding the bead, the adherent coating consisting of a rigid, substantially dried layer formed *in situ* and containing a major proportion of silica.

6. Sphere lenses according to claim 5 having colouring material in the adherent coating thereof.

7. Sphere lenses according to claim 5 or claim 6 in which the glass beads have a refractive index of at least 1.7.

8. Sphere lenses according to any of claims 5 to 7 in which the coating layer consists essentially of silica gel.

9. Sphere lenses according to any of claims 5 to 8 having an approximately hemispherical reflector coating completely surrounded by the adherent transparent coating.

10. Transparent sphere lenses substantially as described herein.

11. A structure adapted for reflex light reflection as herein described, comprising (1) a layer including transparent sphere lenses in accordance with any of claims 5 to 9 and (2) light reflecting means positioned in optical relation with the back extremities of the beads so as to produce reflex reflection of a beam of light through the beads.

12. A structure according to claim 11 comprising additionally (3) colouring material between but not covering the sphere lenses and differing in colour-imparting properties from the sphere lenses so as to cause the front of the structure to simulate a continuous painted appearance when viewed by day which is different from the appearance when viewed by night reflex reflection.

13. A structure adapted for reflex light reflection substantially as described with reference to the accompanying drawing.

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877,083 COMPLETE SPECIFICATION

1 SHEET

*This drawing is a reproduction of
the Original on a reduced scale.*

FIG. 1.

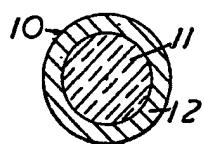


FIG. 2.

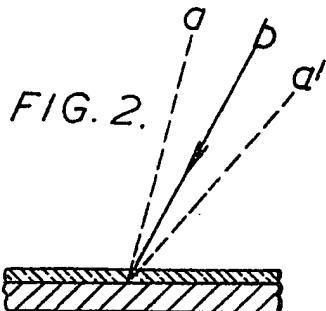


FIG. 3.

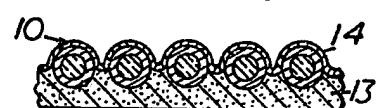


FIG. 4.

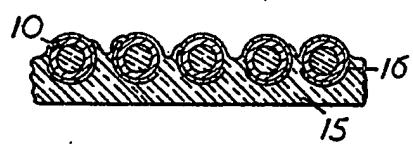


FIG. 5.

